June 10, 1941. J. C. SHERMAN 2,245,014

STRETCHABLE PAPER

Filed Aug. 29, 1936 3 Sheets-Sheet 1

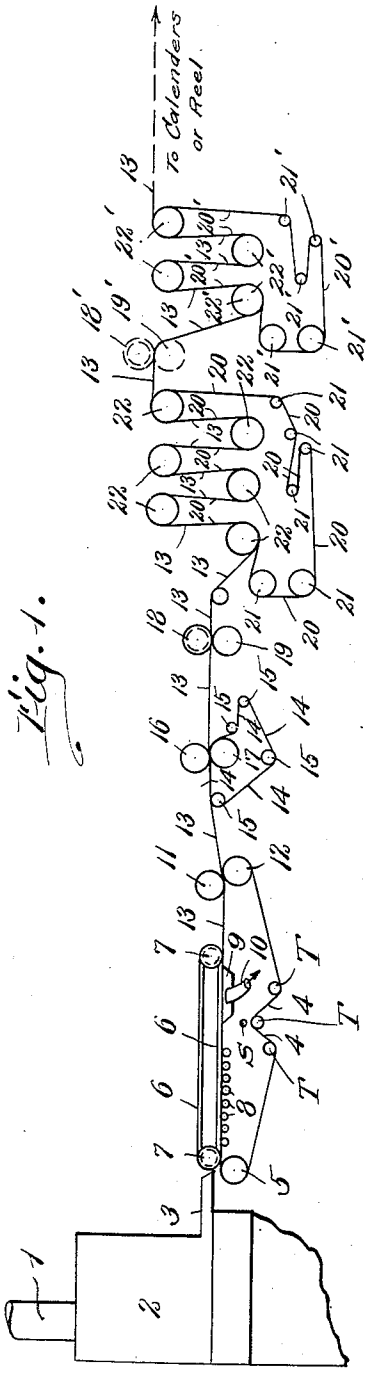

Fig. 1.

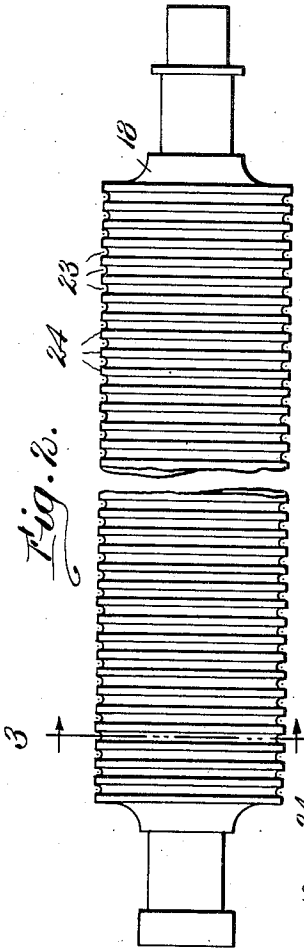

Fig. 2.

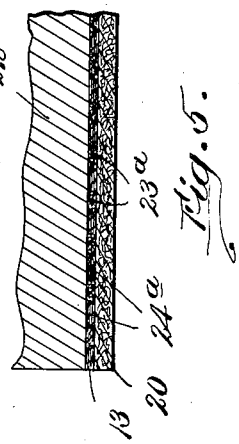

Fig. 5.

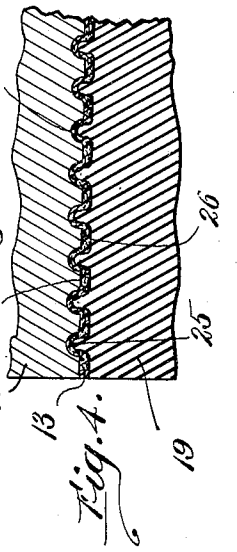

Fig. 4.

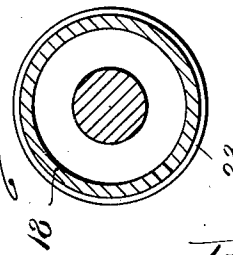

Fig. 3.

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Fig. 6.

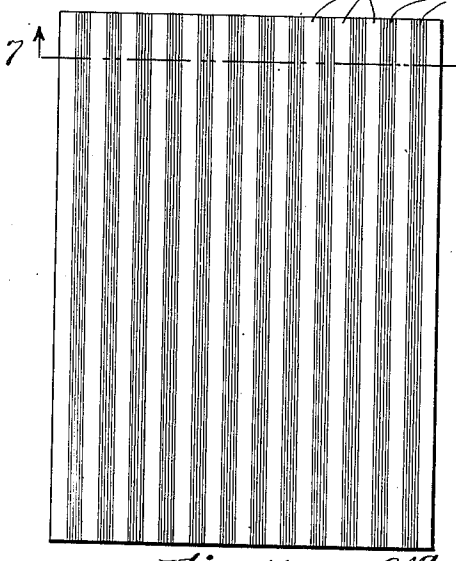


Fig. 8.

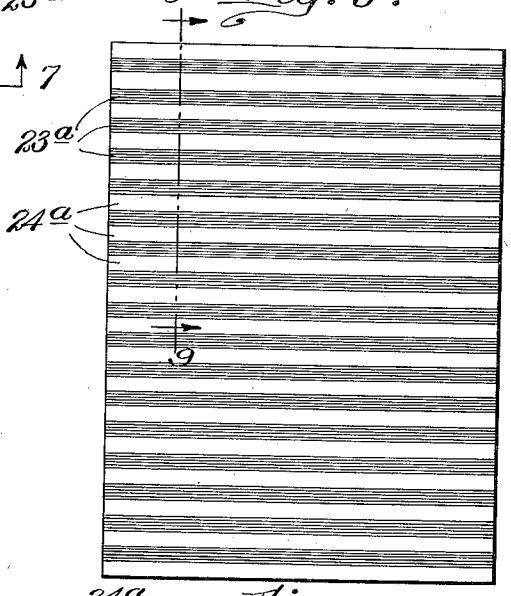


Fig. 7.

Fig. 9.

Fig. 10.

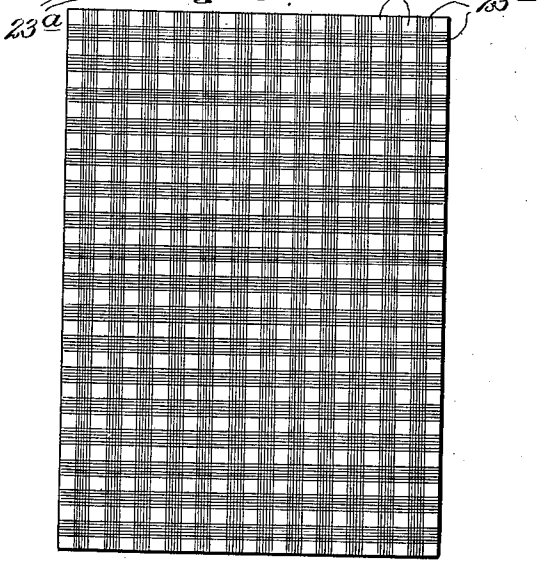
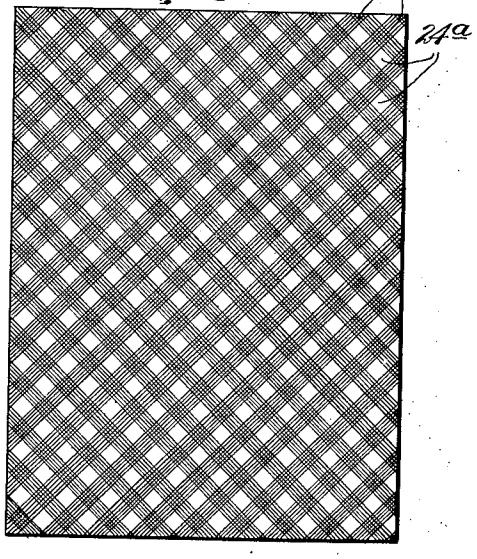


Fig. 11.



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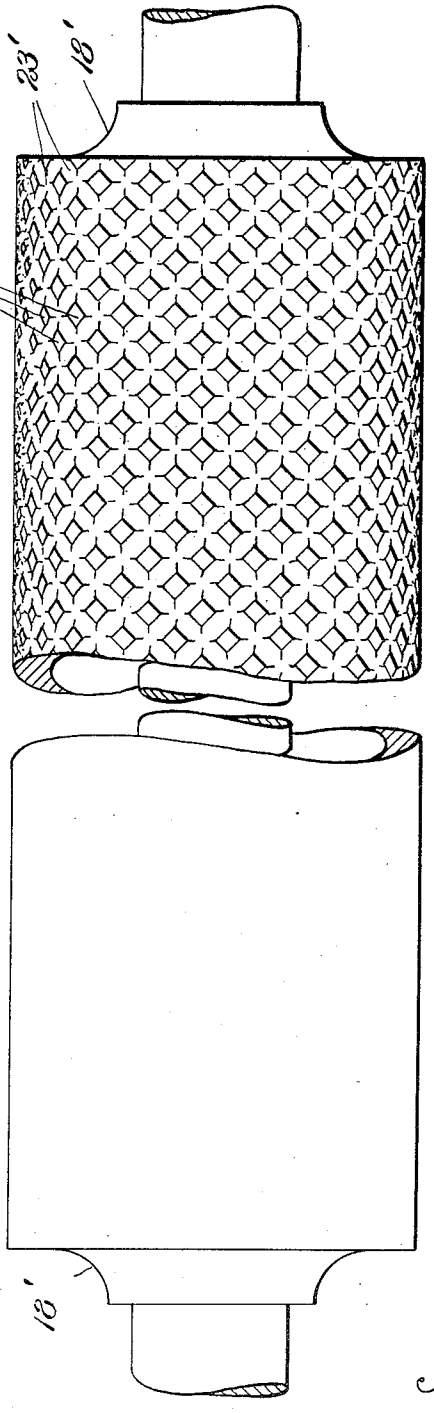

Fig. 18.

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2,245,014

UNITED STATES PATENT OFFICE

2,245,014

STRETCHABLE PAPER

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Application August 29, 1936, Serial No. 98,511

4 Claims. (Cl. 92—39)

This invention relates to paper making; more especially to the making of paper that is capable of stretching in one or more directions, on the usual paper making machinery as modified only to the extent required to carry out this invention.

The need of a paper that will stretch is recognized, and is ordinarily met by applying to the paper-making machine a scraping or "doctor" blade which rests against a roller over which the film of paper passes while wet. This blade causes the wet film to leave the doctoring device with crinkles which ordinarily run across it. Such crinkled film is next carefully dried and, to some extent, its crinkled formation persists through drying and subsequent operations.

However, for certain purposes, a creped-paper sheet is not satisfactory. It necessarily possesses the appearance of crepe though a smoother face would often be desired. Creping the paper necessarily reduces its area per pound of pulp for a given weight-basis of paper. It also requires some slowing down of the paper-making process, ordinarily, because it is less readily dried, since its roughened surfaces do not meet efficiently the usual drying apparatus.

Moreover if I wish to produce paper capable of stretching transversely of the sheet I find the "doctor" blade method unsatisfactory since it produces expansibility in the paper in the longitudinal line, and such creping does not add to the transverse stretchability of the paper.

If, by contrast, one sets up apparatus to crepe or crumple the paper with crinkles placed to give it transverse stretchability, the cost of the creping or crumpling operation is further increased.

Other expedients than creping are known and practiced; for instance, the plaiting of paper may be noted. This involves plaiting the sheet, that is, doubling it back upon itself in folds or ruffles. Or the paper-furnish may contain rubber latex along with the cellulosic elements and thus, if not too heavily calendered, the sheet will stretch to a limited extent, even while maintaining a relatively smooth surface.

On the score of cost, these latter expedients are more burdensome than the usual creping process.

My invention provides an essentially flat-surfaced sheet of paper capable of stretching in any designated direction, or in a plurality of directions, to such extent of stretch as suffices for many commercial and industrial uses; and without any material addition to the normal paper-making costs; and without reduction of the covering-power of the sheet. That is, I may produce a sheet of (e. g) forty-pound weight basis which has to some extent the normal characteristics of the conventional forty-pound sheet but which will, in addition, stretch in one or more directions when strained, without rupture.

In carrying out my invention I have taken cognizance of the fact that when the film of wet pulp leaves the usual Fourdrinier-machine screen, or the like, it is composed, roughly speaking, of three pounds of water associated with every one pound of fibre calculated on the air-dry weight of such fibre.

If, in the usual paper-making operation, this film of wet pulp is next carried through squeeze rolls, and thence to the usual drying apparatus, it loses more and more of its initial water content until at last the resulting paper becomes substantially dry or, as it is called "air" dry.

However, the progressive removal of water from the pulp is determined, stage after stage, by the squeezing and drying apparatus through which it passes. Thus, to consider an illustrative example, a so-called "sulphite" pulp may flow onto the paper-making screen with one part of solid components along with 99 of water, and may leave the screen as a fairly consolidated film with its solids raised to 25 parts of the solid components along with 75 parts of water. It then undergoes some further dewatering by being passed through a succession of squeezing or pressing rolls and may leave the last of these, on its way to be dried, with its solids raised (e. g.) to 30 per cent.

During the stages intervening between its removal from the screen and its subsequent entrance into the remoter sections of the drying system, the wet film of partly-consolidated paper-making material may be considered to be ductile. Its component fibres have not yet become so stoutly interfelted or so firmly bonded by whatever ligneous solids or additive sizing materials it may contain that the film will resist moderate stretching or embossing or other shape-changing agencies of like character.

In my invention I have taken cognizance of this plasticity or ductility of the wet film and used it for a novel purpose. Briefly described, my invention consists in subjecting this wet film to the action of fluted rollers or of one fluted roller opposed, on the opposite face of the film, by a resilient or yieldable roller or the like, and

thus causing it to be stretched along selected paths or zones, after which I cause the film as a whole to undergo the usual compacting and drying operation in a manner to force the stretch zones to go back into the general plane of the film without essentially altering either the lateral or the longitudinal dimension of the film as a whole; that is, with no appreciable change of its weight-basis. By "weight-basis" I mean the recognized basis as defined by stating the air-dry weight of a ream of such paper of designated dimensions.

Obviously my wet film, when fluted by my rollers, becomes within those fluted portions, of less basis-weight than that of the unaffected flat areas of the film. But obviously also when these fluted portions are next crushed back to the approximately planar formation of the film then any given area of such first-fluted-and-then-crushed area resumes its initial weight basis.

However, in the fluting of any element of my film I necessarily disturb the felted formation that was natural to the particular pulp and the particular paper-making process used. I have to some extent forced the fibres from their initial lie in the film. Thus in a characteristic flute, as I form it, having width of $\frac{1}{16}$ inch, and a substantially semi-circular shape, the width of the pulp lying on such flute was originally $\frac{1}{16}$ inch, but becomes $\frac{157}{1000}$ approximately when forced into the flute to fill it. Momentarily, therefore, its weight-basis drops in that proportion, and its component fibres are disturbed and pulled apart correspondingly.

If, next, the film so fluted is quickly pressed back to essential planar form, these disturbed fibres, having no means of reforming themselves to their original position, and having nowhere else to go, go back in a helter-skelter mass to form again into the original $\frac{1}{16}$ inch width. They therefore take on, in this operation a formation that the paper-maker would recognize as "wild"; a formation characterized by little if any general orientation of the fibres, but by their being assembled or jumbled in all directions and compacted into a film of the original weight-basis while so jumbled.

I have found that fibres subjected to this novel operation give to the sheet comprised in part of such fibres what I call a latent stretchability. The sheet may have a substantially uninterrupted flatness of surface, and yet the fluted and recompacted zones possess the quality of stretching under severe tension imposed on the sheet as a whole.

In the accompanying drawings—

Fig. 1 is a diagrammatic cross sectional elevation in a longitudinal plane of a paper making machine showing my fluted roll placed in my preferred position, and an alternative position of said roll suitably indicated;

Fig. 2 is a longitudinal elevation of a roll as used by me showing depressions or flutes running circumferentially thereof;

Fig. 3 is a cross section of this roll taken in the plane 3—3 of Fig. 2;

Fig. 4 is a fragmentary longitudinal cross sectional view of a wall of the roll of Fig. 2 resting upon a resilient roll beneath it, the two rolls confining between them a wet pulp film undergoing the operation of being fluted while wet.

Fig. 5 shows in cross sectional longitudinal elevation part of a drying can, a dryer felt and, between the can and the felt the pulp film from Fig. 4 in process of being restored to relative flatness of form.

Fig. 6 is a plan view of a fragment of paper formed in accord with my invention;

Fig. 7 is a cross section on the line 7—7 of Fig. 6;

Fig. 8 is a plan view of a fragment of paper also formed in accord with my invention but by means of a roll whereof the flutes run longitudinally of said roll;

Fig. 9 is a cross section on the line 9—9 of Fig. 8;

Figs. 10 and 11 illustrate other types of paper as affected by the fluted roll of my invention, said roll being fluted appropriately to form such type.

Fig. 12 shows in partly developed longitudinal elevation a roll which is cut or fluted to give to the paper of Fig. 11 the structure there shown.

In these drawings 1 represents a supply-source of pulp. 2 is the chest or reservoir of pulp delivering to the Fourdrinier screen over the usual apron 3.

The pulp-stock flows over the apron onto the paper-making screen 4 which moves rapidly to the right.

This screen is endless, and is supported by the breast-roll 5 at the place where it receives the pulp stock.

The pulp-stock, flowing from 2 over 3 onto 4 is kept from spilling laterally off the screen by the usual deckle straps 6 mounted on the rotatable and suitably flanged wheels 7.

The screen is in part supported, and the pulp partly dewatered by a system of table rolls 8 contacting the under face of the screen. The pulp may be further dewatered by one or more suction boxes, 9, placed under the screen and evacuated through the suction outlet 10.

At its limit furthest from the pulp supply the screen 4 passes under a couch roll 11, which may be a suction roll for the further dewatering of the pulp, said screen returning on itself around the roll 12, after which it passes over and under the guiding and stretch rolls T, T, T to the roll 5.

At S is indicated a shower pipe to wash off residual pulp.

The film of wet pulp as formed on this screen is indicated throughout the drawings by the number 13.

Leaving the couch roll 11 the film 13 passes to a press roll assembly or to a series of two or more such assemblies.

A single press-roll assembly is shown in Fig. 1. Its operating parts are an endless felt 14, two press rolls 16 and 17 and suitable guiding and tensioning rolls 15. The film 13 which here passes onto the felt 14 is squeezed between the rollers 16 and 17.

After undergoing such squeezing, whether from one or more press-roll assemblies, the film of pulp may now be passed between rollers 18 and 19, one of which, here shown as the upper roll 18, may be grooved circumferentially with a system of grooves to be hereinafter more fully described. The other roll, in this instance the lower roll 19, may have a resilient and yieldable surfacing material such as vulcanized rubber or may be covered with a tubular dryer felt shrunk upon it in a manner familiar to paper-makers.

Passing from between these two rollers the film now enters any convenient drying system here indicated as a series of drying cans.

The dryer assemblage, as indicated, consists typically, but not necessarily, of two horizontal

series or rotating cylinders or cans 22, one such row being above the other, these cylinders being usually kept hot by steam fed suitably to their hollow interiors.

On its passage through the drying assembly the film is carried on the usual dryer felt 20 which is guided and controlled through the usual take-up and carrying rollers 21. The cylinders 22 are rotated suitably to carry the dryer felt 20 and the film 13 continuously forward at the proper speed.

It will be understood that the apparatus above described consists in practice of the parts shown and numerous accessory parts not shown for the better driving, conditioning and control thereof. Such apparatus, however, is in its general plan and arrangement well known to paper-makers, and details not specially pertinent to my invention are in some instances omitted for the sake of simplicity of explanation.

On leaving this system of dryers the now partially dewatered film of paper passes off to the right to a second system of dryers. This second system of dryers is shown in Fig. 1 with its parts numbered like the parts of the first and above-described system, the felt being numbered 20', the dryer cans 22' and the guiding and take up rolls for the felt 21'.

The rolls numbered 18' and 19' indicate an alternative placement of the rolls 18 and 19 to be hereinafter more particularly noted.

In practice many pairs of the dryer cylinders 22 and 22' may be employed, and in carrying out my invention these and also any preferred type of calendering stack may be utilized or the calendering operation may be omitted.

In Fig. 2 the roll 18 of Fig. 1 is shown in broken longitudinal elevation and the depressions or flutes turned in the wall thereof are indicated as at 23. Certain portions of the roll may be left unfluted and these are suggested at 24.

In Fig. 3 a typical flute shows at 23 in the cross-sectional view of the roll 18.

In Fig. 4 the wet pulp film 13 is shown deformed out of its initially planar form by the action of roll 18 yieldably resisted by the roll 19. It should be noted that in any region such as 25, where the film is being deformed, it is thinned materially by being stretched and deformed. By contrast unaffected portions of the film, as 26, maintain more clearly their initial thickness.

In Fig. 5 where the deformed wet film has passed from between the rolls 18 and 19 to the first dryer felt 20 and is held by that felt in contact with the drying cylinder 22, said film now appears flat at 13. It has been flattened, however, without change of the transverse dimension, i. e., the width of the sheet of paper which it is to constitute. A detail of said sheet of paper is shown as a planar view in Fig. 6 in which, as also in Fig. 5, the deformed and flattened regions are shown at 23*a* and the unaffected areas, if any, at 24*a*.

The alterations of structure to which the process of this invention subjects the wet pulp film may more easily be noted from Fig. 7 taken on the line 7—7 of Fig. 6. Here the unaffected regions of the film appear as at 24*a* with their component fibres lying more or less flat and horizontally disposed as they were initially deposited from the paper-making stock upon the screen 4 of Fig. 1.

Other regions as shown at 23*a* were also initially deposited on the screen in the same flat formation but, having now been forced out of such formation by the roll 18 and promptly pushed back by the dryer felt 20, fibres so affected have no chance to resume their original position which was more or less in a horizontal plane, but are crowded and crumpled upon themselves. When the sheet is subsequently pulled to place it under tension these crumpled fibres will to a considerable extent yield to such tension without rupture and so give to the film or sheet some extra stretchability. When so pulled, however, a sheet formed in accord with my invention has been found to retain substantially its normal tensile strength.

In Fig. 8 is shown, in plan, a specimen of paper formed under my invention but with the flutes 23 of the roll 18 of Figs. 2, 3, etc. cut longitudinally of the roll-face and not circumferentially. In Fig. 8 parts are numbered as in Fig. 6.

Fig. 9 is a cross-sectional representation of the sheet of Fig. 8 cut on the line 9—9 thereof and shows the formation of the sheet as described for, and shown in Fig. 7.

Fig. 10 represents, in plan, a piece of paper formed under my invention but with the roll 18 of Figs. 2, 3, etc. cut with flutes running both circumferentially and longitudinally thereof.

Fig. 11 represents paper which has been affected by a fluted roller 18 of Fig. 1, etc. on which the flutes have been cut in two series of spiral lines, the two series being one at an angle to the other, the angle in this instance being 90°.

Fig. 12 shows in partial elevation my fluting roll 18 as cut with appropriate spiral grooves to produce in the paper the effect shown in Fig. 11.

The preferred operation of my new process, having thus been described and illustrated, it remains to be noted that I have placed the rolls 18 and 19 in a position along the general line of the paper making machine where the film of pulp, broadly speaking, comprises 300 pounds of water and 100 pounds of fibre calculated as air-dry fibre.

At that stage of wetness I have found that a film of pulp, when passing through the machine on the way to be dried, is in the best condition to endure without gross rupture and without even the occasioning of small "pin-hole" perforations, the momentary strains that my method puts upon it.

However, if one is applying my invention to a pulp film constituted of very short or very severely beaten fibres, the stated water-content gives to such film sufficient momentary weakness of structure to make it incapable of withstanding, without rupture, the heaviest fluting that I may wish to impress on it.

In such instances it is desirable to remove the rolls 18 and 19 from contact with the wet film at the point indicated at 18 and 19 in Fig. 1 and not to place them in contact with it until said film has passed part way through the dryer system. Thus in Fig. 1 the rolls 18 and 19 may be considered as placed to the right of the small group of dryer cans 22, 22, where they appear as circles defined by dotted lines the film having passed through this initial dryer system being then sent through a second dryer system 20', 21' and 22' to carry on the drying operation. In such event the fluted film is nipped between the first dryer can of the 22' series, and its associated dryer felt 20' for the purpose of flattening the flutes precisely as is done in the operation described above.

Ordinarily, on leaving the last of the dryer system parts, a sheet of paper passes through

suitable calenders to a winding-up drum from which it may be re-reeled, slitted or otherwise treated. But there are certain types of paper, more especially papers that have been softened as by the incorporation in them of glycerine or the like plasticizer, to which my invention may be applied when the paper has become substantially dewatered. This comment relates also to soft papers of low density such as are usually called felts and as such known to the roofing, artificial leather and other industries, which have been to some extent impregnated with a water-dispersion of rubber, such as natural latex or emulsified and water-dispersed rubber. Such papers and felts will endure my process of fluting and subsequently flattening them even after the normal paper-making process has been applied to them in toto. In such instances I may apply my invention to such papers or such felts in an air-dry condition, that is, the condition which they show under atmospheric exposure but with enough inherent plasticity to endure my process. In such event my rolls 18 and 19 may be placed after the last dryer system or indeed to sheets and rolls of paper or felt at any later period.

It is of the essence of my invention that my fluting and flattening operations shall be applied to the sheet or the felt when it is in a condition of such plasticity that it will endure without destruction the successive operations of deforming it into a fluted condition and then substantially flattening it.

Having thus exemplified my invention without limitation to the precise instances narrated above, I claim:

1. The method of forming stretchable paper, which consists in fluting a wet paper forming pulp in continuous parallel zones alternating with unfluted parallel zones which separate the fluted parallel zones and then subjecting the fluted parallel zones to pressure while still wet to cause the fluted zones to revert essentially to their initial flat condition.

2. The process of imparting to paper spaced and uninterrupted zones of stretchability alternating with less stretchable zones which consists in fluting a wet fibrous paper forming pulp to depress said web only along continuous fluted zones, and then immediately compressing said depressed areas of the web to force them back within marginal limits of said originally fluted areas, thereby restoring the essential planar formation of the web, and then drying the web.

3. The method of producing an essentially flat paper sheet capable of being stretched when stressed, without rupture, which consists in initially impressing upon the wet paper forming pulp systems of spaced and parallel continuous zones of fluting alternating with unfluted portions, and then compressing the fluted zones to force them to resume their initially flat conformation within the defining limits of said fluted zones, the areas of the alternating unfluted portions of the sheet intermediate said zones remaining substantially unaffected and then drying the sheet.

4. The method of imparting stretchability to a sheet of paper which consists in pressing a sheet of paper-forming pulp, containing not less than approximately 70% water by weight, to form flutings therein and subsequently subjecting the flutings to pressure to cause them to revert substantially to their initial flat condition while said sheet still contains not less than approximately 70% water by weight.

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